AVIAN SPECIES INVOLVED IN POLLINATION AND SEED DISPERSAL OF SOME FORESTRY SPECIES IN HIMACHAL PRADESH[1]

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Key words: Pollination, *Bombax ceiba* Linn., *Celtis australis* Linn., seed eaters, Pycnonotidae

Studies on avian species involved in pollination and seed dispersal of some forestry species have been carried out since 1994 in the University campus at Nauni, Solan in Himachal Pradesh. During the study, 31 species of birds belonging to 13 families and 4 orders were recorded interacting with 28 species of trees and shrubs. Of the 31 species of birds recorded, 10 were involved in pollination alone, another 10 contributed to pollination and seed dispersal, while 8 species were involved in seed dispersal only. The remaining 3 species, all parakeets, were found to be seed eaters, though two of them were involved in pollination. Our study revealed that relative abundance of bulbuls (Family: Pycnonotidae) was very high, as nectarivores and as seed dispersal agents, followed by mynas (Family: Sturnidae). The members of the family Pycnonotidae are, therefore, important agents in cross pollination and also in seed dispersal.

Introduction

The 1,200 species of birds found in India constitute an important component of our agro- and forest ecosystems. It is well recognised now that birds play an important role in shaping our economy. Realising the importance of birds for an agricultural country like India, Sálim Ali (1936) laid the foundation of economic ornithology. The literature on economic ornithology as reviewed by Mehrotra and Bhatnagar (1979), and recently by Dhindsa and Saini (1994), suggest that the role of birds in relation to agriculture and horticulture has received the attention of many workers (Mason and Lefroy 1912, Hussain and Bhalla 1937, Mukherjee 1969-76, Toor and Ramzan 1974, Mathew *et al.* 1980, Narang and Lamba 1984 and Narang 1986). Scientists working under the All India Network Programme (AINP) on Agricultural Ornithology have also contributed to the subject. However, the role of birds in pollination and seed dispersal of various forestry species has received little attention from Indian ornithologists so far. The literature on pollination by birds was reviewed by Subramanya and Radhamani (1993). According to them, the role of birds in pollination was studied by Singh 1929, Ali 1932, Kannan 1980 and Davidar 1985. Several publications on birds feeding on wild fruits are available (Ali 1931, Faruqui *et al.* 1960, Howe and Estabrook 1977, Shahabuddin 1993, Balasubramanian 1995, 1996 and Rajsekhar 1995).

This work was aimed to (i) study the bird species involved in the pollination of *Bombax ceiba* Linn. and the seed dispersal of *Morus alba* Linn., *Celtis australis* Linn. and a shrub *Coriaria nepalensis* Wall., and (ii) to record in general the bird species involved in pollination and seed dispersal of some important forest trees/shrubs.

Material and Methods

The study initiated in 1994 was carried out at the Nauni campus of the University of Horticulture and Forestry, Solan (30° 50' N, 77° 11' E and 1,250 m above msl). The campus is spread over an area of 550 ha, most of it under agroforestry ecosystems. Approximately 200 species of trees and shrubs have been recorded from the campus so far (Sindhi 1996).

The study area was visited twice a week in the morning for one hour and tree-bird

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interactions recorded using 7x50 field binoculars. Ten trees each of *Bombax ceiba* (Linn.), *Morus alba* Linn. and *Celtis australis* Linn. were identified as study sites. Record of birds with remarks, whether feeding on nectar or fruit, was maintained for each tree/shrub and for each visit. Data pertaining to bird species diversity per tree/ shrub and their relative abundance was also recorded.

Results and Discussion

A total of 31 species of birds (Table 1) belonging to 13 families and 4 orders were recorded interacting with 28 species of trees and shrubs (Table 2). Out of the 31 species of birds recorded, 10 were involved in pollination alone, 10 contributed to pollination and seed dispersal, while 8 species were agents of seed dispersal only (Table 1). The slatyheaded parakeet *Psittacula himalayana* was recorded to be a seed eater, whereas the Alexandrine parakeet *Psittacula eupatria* and plum-headed parakeet *Psittacula cyanocephala,* though contributing to cross pollination, did not contribute to seed dispersal, and were found to be seed eaters.

Birds as pollinators: During the present study, 22 species of birds were recorded sipping nectar from 11 tree species, 2 shrubs and 2 ornamental plants (Table 3). While doing so, the bill and forehead of the bird gets smeared with pollen. The birds feeding on nectar, therefore, contribute to the cross pollination of trees, shrubs and ornamental plants visited by them.

A total of 58 bird species belonging to 16 families and 4 orders have been recorded as flower birds (Subramanya and Radhamani 1993). During this study, 9 more have been recorded as pollinators, taking the total to 67. Nearly 70% of the bird species frequented more than one species of plant for nectar (Table 3).

The semal tree *Bombax ceiba* Linn., which flowers during March-April, was the most preferred tree species. A total of 19 species of birds were observed sipping nectar on semal (Table 4), followed by coral tree *Erythrina indica* Lamk., which attracted 11 bird species. *Woodfordia floribunda* Salisb., which flowers during April-May, was visited by 8 bird species. During this period, the forehead of oriental white-eye *Zosterops palpebrosus* was found smeared with brown pollen grains, the result of its feeding on the nectar of *Woodfordia floribunda* Salisb., during which the pollen was brushed on to the forehead. Another ornithophilous tree *Butea monosperma* (Lamk.) Taub. was visited by 5 bird

TABLE 1
BIRD COMMUNITY VISITING FOREST SPECIES FOR NECTAR (N) AND FRUITS (F)

Bird species		N/F
Common Name	Scientific Name	
Alexandrine parakeet	*Psittacula eupatria*	N & F (P)
Plum-headed parakeet	*Psittacula cyanocephala*	N & F (P)
Slatyheaded parakeet	*Psittacula himalayana*	F(P)
Asian koel	*Eudynamys scolopacea*	F
Great barbet	*Megalaima virens*	F
Bluethroated barbet	*Megalaima asiatica*	F
Eurasian golden oriole	*Oriolus oriolus*	F
Spot-winged starling	*Saroglossa spiloptera*	N
Chestnut-tailed starling	*Sturnus malabaricus*	N
Common myna	*Acridotheres tristis*	N&F
Jungle myna	*Acridotheres fuscus*	N&F
Redbilled blue magpie	*Urocissa erythrorhyncha*	N&F
Large-billed crow	*Corvus macrorhynchos*	N&F
Rufous treepie	*Dendrocitta vagabunda*	F
Grey treepie	*Dendrocitta formosae*	F
Himalayan bulbul	*Pycnonotus leucogenys*	N&F
Redvented bulbul	*Pycnonotus cafer*	N&F
Black bulbul	*Hypsipetes madagascariensis*	N&F
Jungle babbler	*Turdoides striatus*	N&F
Redbilled leiothrix	*Leiothrix lutea*	F
Rufous sibia	*Heterophasia capistrata*	N
Flycatcher	*Muscicapa* sp.	N
Grey-hooded warbler	*Seicercus xanthoschistos*	N
Dark-throated thrush	*Turdus ruficollis*	F
Great tit	*Parus major*	N
Purple sunbird	*Nectarinia asiatica*	N
Crimson sunbird	*Aethopyga siparaja*	N
Oriental white-eye	*Zosterops palpebrosus*	N&F
House sparrow	*Passer domesticus*	N
Russet sparrow	*Passer rutilans*	N
Common rosefinch	*Carpodacus erythrinus*	N&F

F(P) : Seed eater

TABLE 2
SPECIES OF PLANTS VISITED BY BIRDS FOR NECTAR (N) OR FRUITS (F)

Plant species	Family	N/F
Bignonia venusta Ker-Gawl.	Bignoniaceae	N
Bombax ceiba Linn.	Bombacaceae	N
Ehretia acuminata R.Br.	Boraginaceae	F
Bauhinia variegata Linn.	Caesalpiniaceae	N
Coriaria nepalensis Wall. (shrub)	Coriariaceae	F
Xylosma longifolium Clos. (off season flowering plant)	Flacourtiaceae	N
Woodfordia floribunda Salisb. (shrub)	Lythraceae	N
Hibiscus mutabilis Linn. (ornamental plant)	Malvaceae	N
Azadirachta indica A. Juss.	Meliaceae	F
Ficus palmata Forsk.	Moraceae	F
Ficus religiosa Linn.	Moraceae	F
Morus alba Linn.	Moraceae	F
Eucalyptus globulus Labill	Myrtaceae	N
Butea monosperma (Lamk.) Taub.	Papilionaceae	N
Erythrina indica Lamk.	Papilionaceae	N
Ougenia oojeinensis (Roxb.)	Papilionaceae	N
Punica granatum Linn.	Punicaceae	N
Crataegus crenulata Roxb.	Rosaceae	F
Prunus cerasoides D. Don. (off season flowering plant)	Rosaceae	N
Prunus sp.	Rosaceae	N
Pyrus pashia Buch.-Ham. ex D. Don	Rosaceae	N N& F
Rosa moschata Hook. (shrub)	Rosaceae	F
Rubus ellipticus Smith (shrub)	Rosaceae	F
Leptodermis lanceolatus Wall. ex DC (shrub)	Rubiaceae	N
Osyrus arborea (Wall.) ex DC (shrub)	Santalaceae	F
Solanum nigrum Linn.	Solanaceae	F
Grewia optiva Drumm. ex Burr.	Tiliaceae	F
Celtis australis Linn.	Urticaceae	F

species. The small bird community of this species could be attributed to its small population in the study area.

Kannan (1980) discovered that flower nectar is an important item of the sunbird's diet. During the present study, purple sunbird *Nectarinia asiatica,* a summer migrant in the University campus, was seen to visit 9 species of bird flowers. The crimson sunbird *Aethopyga siparaja* was recorded frequenting two species of ornamental plants, namely *Hibiscus mutabilis* Linn., *Bignonia venusta* Ker-Gawl., a climber and *Woodfordia floribunda* Salisb., a shrub. Crimson sunbirds were, however, partial to the nectar of ornamental plants, which they were observed sipping through the regular flower opening, and had also adopted a short cut method to reach the nectar. Even the unopened flowers of *Hibiscus mutabilis* Linn. were robbed of their nectar by these birds.

A few species of trees/shrubs flower during September-November, when the breeding season of birds is over. The Oriental white-eye *Zosterops palpebrosus,* a specialized nectar-feeder, was observed visiting *Leptodermis lanceolatus* Wall., a shrub that flowers after the birds' breeding season. It also visited *Prunus cerasoides* D. Don., a plant flowering outside the breeding period, for nectar. The Himalayan bulbul *Pycnonotus leucogenys,* a non-specialized nectar-feeder, was also recorded frequenting the plants of *Prunus cerasoides* D. Don. for nectar during its non-breeding period in September-October.

Kannan (1980) has termed the Nectariniidae (sunbirds), Zosteropidae (white-eyes), Irenidae (leafbirds) and Dicaeidae (flowerpeckers) as specialized nectar-feeders among Indian birds. Out of these, sunbirds and white-eyes are the important flower birds (i.e. flower visitors) of the study area (Table 3). Leafbirds are not represented in the study area, and flowerpeckers are rare during the flowering period. Amongst the non-specialized nectar-feeders, bulbuls (Pycnonotidae) especially the Himalayan bulbul *Pycnonotus leucogenys,* were found to be the prominent nectar-feeders, followed by mynas and starlings (Sturnidae).

Birds as seed dispersal agents: As per our study, 21 bird species belonging to 10 families were observed feeding on the fruits of 14 plant species, which include 5 shrubs and a herb (Table 5). Out of the 21 avian species observed feeding on fruits, 3 species of parakeets were found to be seed eaters and did not help in seed dispersal. The two resident species of parakeets i.e. *Psittacula eupatria* and *Psittacula cyanocephala* were recorded as feeding on and rendering

TABLE 3
FLOWER BIRDS OF THE STUDY AREA AND PLANT SPECIES VISITED BY THEM

Bird species		Plant species visited
Common Name	Scientific Name	
Alexandrine parakeet	*Psittacula eupatria*	*Bombax ceiba* Linn.
Plum-headed parakeet	*Psittacula cyanocephala*	*Bombax ceiba* Linn.
Spot-winged starling	*Saroglossa spiloptera*	*Bombax ceiba* Linn. *Woodfordia floribunda* Salisb.
Chestnut-tailed starling	*Sturnus malabaricus*	*Bombax ceiba* Linn. *Butea monosperma* (Lamk.) Taub. *Woodfordia floribunda* Salisb.
Common myna	*Acridotheres tristis*	*Bombax ceiba* Linn. *Erythrina indica* Lamk. *Butea monosperma* (Lamk.) Taub. *Eucalyptus globulus* Labill.
Jungle myna	*Acridotheres fuscus*	*Bombax ceiba* Linn. *Erythrina indica* Lamk. *Butea monosperma* (Lamk.) Taub.
Large-billed crow	*Corvus macrorhynchos*	*Bombax ceiba* Linn. *Erythrina indica* Lamk.
Redbilled blue magpie	*Urocissa erythrorhyncha*	*Bombax ceiba* Linn.
Himalayan bulbul	*Pycnonotus leucogenys*	*Bombax ceiba* Linn. *Woodfordia floribunda* Salisb. *Erythrina indica* Lamk. *Prunus cerasoides* D. Don. *Prunus* sp. *Xylosma longifolium* Clos.
Redvented bulbul	*Pycnonotus cafer*	*Bombax ceiba* Linn. *Erythrina indica* Lamk.
Black bulbul	*Hypsipetes madagascariensis*	*Bombax ceiba* Linn. *Erythrina indica* Lamk.
Jungle babbler	*Turdoides striatus*	*Bombax ceiba* Linn. *Erythrina indica* Lamk. *Butea monosperma* (Lamk.) Taub.
Rufous sibia	*Heterophasia capistrata*	*Bombax ceiba* Linn. *Erythrina indica* Lamk.
Flycatcher	*Muscicapa* sp.	*Bombax ceiba* Linn. *Woodfordia floribunda* Salisb.
Grey-hooded warbler	*Seicercus xanthoschistos*	*Ougenia oojeinensis* (Roxb.)
Great tit	*Parus major*	*Bombax ceiba* Linn.
Purple sunbird	*Nectarinia asiatica*	*Bombax ceiba* Linn. *Woodfordia floribunda* Salisb. *Erythrina indica* Lamk. *Butea monosperma* (Lamk.) Taub. *Pyrus pashia* Buch.-Ham. ex D. Don *Prunus* sp. *Bauhinia variegata* Linn. *Punica granatum* Linn. *Bignonia venusta* Ker-Gawl.
Crimson sunbird	*Aethopyga siparaja*	*Hibiscus mutabilis* Linn. *Bignonia venusta* Ker-Gawl. *Woodfordia floribunda* Salisb.

TABLE 3 (CONTD.)
FLOWER BIRDS OF THE STUDY AREA AND PLANT SPECIES VISITED BY THEM

Bird species		Plant species visited
Common Name	Scientific Name	
Oriental white-eye	*Zosterops palpebrosus*	*Bombax ceiba* Linn. *Erythrina indica* Lamk. *Woodfordia floribunda* Salisb. *Ougenia oojeinensis* (Roxb.) *Prunus cerasoides* D. Don. *Prunus* sp. *Pyrus pashia* Buch.-Ham. ex D. Don *Leptodermis lanceolatus* Wall.
House sparrow	*Passer domesticus*	*Bombax ceiba* Linn. *Erythrina indica* Lamk.
Russet sparrow	*Passer rutilans*	*Bombax ceiba* Linn.
Common rosefinch	*Carpodacus erythrinus*	*Woodfordia floribunda* Salisb.

TABLE 4
RELATIVE ABUNDANCE OF BIRDS ON FOUR PLANT SPECIES

Bird species		Relative abundance (%)			
Common Name	Scientific Name	1	2	3	4
Alexandrine parakeet	*Psittacula eupatria*	3.22	-	*.656	-
Plum-headed parakeet	*Psittacula cyanocephala*	6.17	-	*5.45	-
Asian koel	*Eudynamys scolopacea*	-	2.08	-	-
Bluethroated barbet	*Megalaima asiatica*	-	-	4.19	-
Eurasian golden oriole	*Oriolus oriolus*	-	-	-	3.17
Spot-winged starling	*Saroglossa spiloptera*	1.46	-	-	-
Chestnut-tailed starling	*Sturnus malabaricus*	2.05	-	-	-
Common myna	*Acridotheres tristis*	2.66	-	26.18	23.80
Jungle myna	*Acridotheres fuscus*	2.71	14.58	-	7.93
Redbilled blue magpie	*Urocissa erythrorhyncha*	1.14	8.33	-	-
Large-billed crow	*Corvus macrorhynchos*	11.20	-	16.36	-
Grey treepie	*Dendrocitta formosae*	-	-	7.27	-
Himalayan bulbul	*Pycnonotus leucogenys*	21.47	20.83	21.44	20.63
Redvented bulbul	*Pycnonotus cafer*	5.18	16.66	2.72	3.17
Black bulbul	*Hypsipetes madagascariensis*	14.34	16.66	4.03	6.34
Jungle babbler	*Turdoides striatus*	5.13	-	-	11.11
Redbilled leiothrix	*Leiothrix lutea*	-	2.08	-	-
Rufous sibia	*Heterophasia capistrata*	3.25	-	-	-
Rufous treepie	*Dendrocitta vagabunda*	-	-	5.75	14.28
Flycatcher (unidentified)	???	0.61	-	-	-
Darkthroated thrush	*Turdus ruficollis*	-	4.16	-	-
Great tit	*Parus major*	4.61	-	-	-
Purple sunbird	*Nectarinia asiatica*	4.14	-	-	-
Oriental white-eye	*Zosterops palpebrosus*	3.07	-	-	9.52
House sparrow	*Passer domesticus*	1.53	-	-	-
Russet sparrow	*Passer rutilans*	6.06	-	-	-
Common rosefinch	*Carpodacus erythrinus*	-	14.58	-	-

1. *Bombax ceiba* Linn. 2. *Morus alba* Linn. 3. *Celtis australis* Linn. 4. *Coriaria nepalensis* Wall.
*Both the species of parakeets are seed eaters

TABLE 5
AVIAN SPECIES INVOLVED IN SEED DISPERSAL

Bird species		Plant visited
Common Name	Scientific Name	
*Alexandrine parakeet	*Psittacula eupatria*	*Celtis australis* Linn.
*Plum-headed parakeet	*Psittacula cyanocephala*	*Celtis australis* Linn.
*Slatyheaded parakeet	*Psittacula himalayana*	*Pyrus pashia* Buch.-Ham. ex D. Don.
Asian koel	*Eudynamys scolopacea*	*Morus alba* Linn.
Great barbet	*Megalaima virens*	*Ficus religiosa* Linn.
Bluethroated barbet	*Megalaima asiatica*	*Ficus religiosa* Linn.
		Celtis australis Linn.
Eurasian golden oriole	*Oriolus oriolus*	*Coriaria nepalensis* Wall.
Common myna	*Acridotheres tristis*	*Celtis australis* Linn.
		Ficus religiosa Linn.
		Ficus palmata Forsk.
		Coriaria nepalensis Wall.
		Solanum nigrum Linn.
Jungle myna	*Acridotheres fuscus*	*Morus alba* Linn.
		Ficus religiosa Linn.
		Coriaria nepalensis Wall.
Redbilled blue magpie	*Urocissa erythrorhyncha*	*Morus alba* Linn.
		Rubus ellipticus Smith
Large-billed crow	*Corvus macrorhynchos*	*Celtis australis* Linn.
Rufous treepie	*Dendrocitta vagabunda*	*Celtis australis* Linn.
		Coriaria nepalensis Wall.
Grey treepie	*Dendrocitta formosae*	*Celtis australis* Linn.
Himalayan bulbul	*Pycnonotus leucogenys*	*Celtis australis* Linn.
		Morus alba Linn.
		Coriaria nepalensis Wall.
		Azadirachta indica A. Juss.
		Ficus religiosa Linn.
		Grewia optiva Drumm. ex Burr.
		Ficus palmata Forsk.
		Crataegus crenulata Roxb.
Redvented bulbul	*Pycnonotus cafer*	*Morus alba* Linn.
		Coriaria nepalensis Wall.
		Grewia optiva Roxb.
		Osyrus arborea (Wall.) ex DC
		Celtis australis Linn.
Black bulbul	*Hypsipetes madagascariensis*	*Azadirachta indica* A. Juss.
		Morus alba Linn.
		Celtis australis Linn.
		Ficus religiosa Linn.
		Rosa moschata Hook.
		Ehretia acuminata R.Br.
		Coriaria nepalensis Wall.
Jungle babbler	*Turdoides striatus*	*Coriaria nepalensis* Wall.
Redbilled leiothrix	*Leiothrix lutea*	*Morus alba* Linn.
Dark-throated thrush	*Turdus ruficollis*	*Morus alba* Linn.
		Ficus religiosa Linn.
Oriental white-eye	*Zosterops palpebrosus*	*Coriaria nepalensis* Wall.
Common rosefinch	*Carpodacus erythrinus*	*Morus alba* Linn.

* Three species of parakeets are seed eaters

unviable the seeds of *Celtis australis* Linn. The third species *Psittacula himalayana,* a winter migrant was recorded to be a seed eater of *Pyrus pashia* (Buch.-Ham. ex D. Don.). The remaining 18 avian frugivores contributed to seed dispersal. The true role of these birds in plant propagation could not be assessed, as the viability of seeds passed out by the birds was not tested.

Maximum bird density was recorded on mulberry trees *Morus alba* Linn. which were visited by 9 bird species in April (Table 4). The red colour of the ripening fruits is probably the reason for high density and diversity of birds, as fruit colour is one of the factors determining fruit choice by birds (Wheelwright and Janson 1985). Mulberry fruit, which constitutes an important food item for birds in the study area, ripens at the same time as the breeding season of birds.

Fruit of khirak *Celtis australis* Linn. starts maturing in August-September. During the early period of ripening, it is eaten by parakeets and barbets. But it is during the winter (December-January) when insect food is reduced, that these trees are visited by 10 species of avian frugivores (Table 4). Maximum species diversity was exhibited on these trees during the winter months. *Celtis australis* Linn. is thus an important fruit crop that sustains 10 species of avian frugivores for nearly half the year. All but the two species of parakeets bring about seed dispersal of this species.

Another forestry species in the study area which is predominantly dispersed through an avian frugivore, the black bulbul *Hypsipetes madagascariensis,* is *Azadirachta indica* A. Juss. Black bulbuls feed almost exclusively on the ripe fruits of *Azadirachta indica* A. Juss. during December-February.

Amongst the shrubs, *Coriaria nepalensis* Wall. was the most preferred. Nine species of avian frugivores were recorded visiting it for fruit during April-May (Table 4). The seeds of this shrub species are, therefore, dispersed mainly by birds.

The results of our study show that the relative abundance of Himalayan bulbul and black bulbul was very high, both as a nectarivore and as a seed dispersal agent (Table 4). Relative abundance of Himalayan bulbul was highest as a nectarivore in respect of *Bombax ceiba* Linn. and as a frugivore in respect of *Morus alba* Linn. The Himalayan bulbul was the second most abundant on *Celtis australis* Linn. and also on *Coriaria nepalensis* Wall. (Table 4). Similarly, the black bulbul was the second most abundant species as a nectarivore of *Bombax ceiba* Linn. and as a frugivore of *Morus alba* Linn. Redvented bulbul was an agent of pollination as well as seed dispersal, but its abundance was poor. Overall, the 3 species of bulbuls were agents of pollination of 6 tree/shrub species and seed dispersal of 11 tree/shrub species. Common myna *Acridotheres tristis,* though it was the most abundant frugivore on *Celtis australis* Linn. and also on *Coriaria nepalensis* Wall., was not recorded on *Morus alba* Linn. and its abundance was poor as a nectarivore. The abundance of other members of the family Sturnidae was also poor, both as nectarivore as well as frugivore. The members of the family Pycnonotidae are, therefore, important agents in cross pollination and also in seed dispersal.

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